

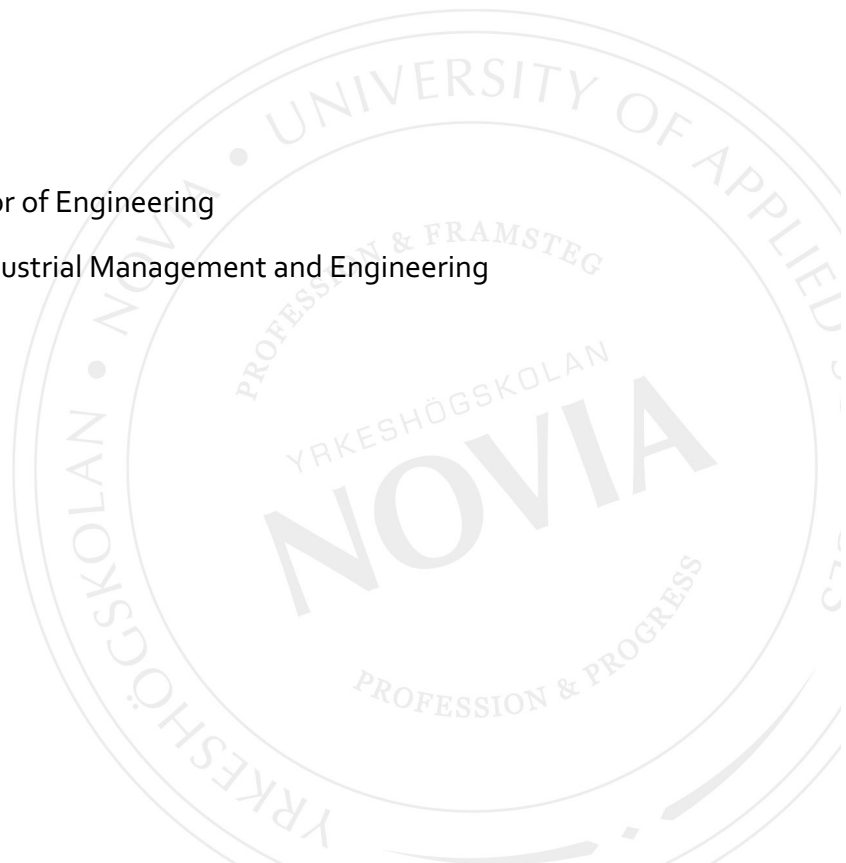
Engine Block Replacement and Stock Optimization

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EXAMENSARBETE

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Abstrakt

Det här examensarbetet är gjort på uppdrag åt Wärtsilä 32 teknisk service. Syftet med detta arbete var att skapa ett hjälpmedel som kan användas när teknisk support ges i samband med ett byte eller en beställning av ett motorblock. En optimerad lagernivå för motorblock har även undersökts, i syftet av kostoptimering och ökad konkurrenskraft i framtiden.

Idag finns det inga specifika ersättningskedjor tillgängliga när det kommer till att byta ut motorblock mellan olika designstadier. Det har förekommit tillfällen då problem med kompatibiliteten mellan ett gammalt och nytt motorblock har uppstått på fältet vid en installation. Detta skapar ett scenario där både kunden och Wärtsilä förlorar tid och pengar på att undersöka vilka delar som behöver modifieras och vilka delar som kan ersätta de felaktiga. Metoderna som använts till detta arbete baseras på teori om kvalitativa intervjuer samt logistik.

Resultatet av detta slutarbete är ett Excel-verktyg med två olika sökfunktioner. Den första funktionen låter användaren söka efter tillgängliga sammansättningar av motorblock baserat på den valda motorkonfigurationen. Sökningen ger ett förslag på ett ersättande motorblock samt visar de största skillnaderna i strukturen mellan det gamla och nya blocket. Den andra sökfunktionen låter användaren söka efter materialnummer för gjutet till motorblock. Sökningen visar enligt vilka olika ritningarna gjutet i fråga har blivit maskinerat samt skillnaderna mellan dessa. Detta verktyg kommer att fungera som hjälpmedel för att i framtiden kunna ge snabbare teknisk support.

Språk: Engelska

Nyckelord: Lageroptimering, lagerhållning, motorblock, Wärtsilä

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Abstract

This thesis is made on the behalf of Wärtsilä 32 technical service. The purpose is to create a tool that will work as an aid to be used when giving technical support for engine block orders and replacements. A suggestion for a recommended stock level is also created in the purpose of cost optimization and better competitiveness in the future.

As of today, there are no specific replacement chains available for replacing engine blocks between different design stages. There have been occasions when problems with the compatibility between an old and new engine block have occurred at the site of the installation. This creates a scenario where both the customer and Wärtsilä lose time and money, trying to figure out which parts need modification and which parts that can replace the inaccurate ones. Methods used to reach the result include theory on qualitative interviews and logistics.

The result of this thesis is an Excel tool with two different search functions. The first function lets the user search for available engine block assemblies based on the chosen engine configuration and thereafter gives a suggestion for a replacement engine block, showing the most significant differences in the structure between the two. The second search function lets the user search for an engine block casting material number in case an assembly number is not available. Based on the material number, the specifications of the engine block casting are shown according to every available main drawing connected to the casting. The tool will assist in giving faster technical support for engine block orders and replacements.

Language: English Key words: Stock optimization, logistics, engine block, Wärtsilä

Table of contents

1	INTRODUCTION	1
1.1	Background	1
1.2	Purpose	2
1.3	Delimitations	2
1.4	Confidentiality	2
1.5	Disposition	3
1.6	Wärtsilä in brief	4
1.6.1	Wärtsilä Marine Solutions	4
1.6.2	Wärtsilä Energy Solutions.....	4
1.6.3	Wärtsilä Services.....	5
1.6.4	Wärtsilä 32 Technical Service	5
2	THEORY	6
2.1	Qualitative research	6
2.1.1	Qualitative data.....	6
2.2	Logistics.....	8
2.2.1	Components of a logistics system.....	9
3	METHOD	11
3.1	Interviews.....	11
3.1.1	Interview with Senior Engine expert, engine structure & power systems.....	11
3.1.2	Interview with Process Developer, block manufacturing.....	12
3.1.3	Interview with Manager for Operations, Engines and components/Strategic Purchaser	12
3.2	Choice of platform	13
3.3	Data collection	13
3.4	Creating the configurator.....	16
3.5	Recommended stock level	16
4	RESULT	17
4.1	Start page	17
4.2	Search assembly function	18
4.2.1	Engine block info.....	19
4.3	Search casting number function	20
4.4	Recommended stock level	21
5	DISCUSSION.....	22
5.1	Summary	22
5.2	Further development.....	23
5.3	Comments	23
6	References.....	24

Table of Figures

Figure 1 List of existing engine block assemblies for W12V32 configuration.....	13
Figure 2 W12V32 engine block assembly overlook	14
Figure 3 Engine block structural differences between design stages.....	15
Figure 4 Main bearing cap design stage differences	15
Figure 5 W12V32 engine block assembly overview.....	16
Figure 6 Start page	17
Figure 7 Search assembly function, configuration choice.....	18
Figure 8 Search assembly function, assembly choice	18
Figure 9 Engine block info	19
Figure 10 Search casting number function, casting choice	20
Figure 11 Engine block casting info.....	20
Figure 12 Recommended stock level for W32 engine blocks.....	21

List of terminology and abbreviations

PDM = Product Data Management, a tool used by Wärtsilä to manage the product information throughout its entire lifecycle.

SAP = Systems, Applications & Products in Data Processing. Enterprise resource planning software used by Wärtsilä to manage business operations.

TS = Technical Service, subdepartment to Wärtsilä Service.

FS = Field Service

SPN = Spare part number, a unique number that specifies the location and function for a part

BOM = Bill of material, a comprehensive list of parts, items, assemblies and other materials required to create a product.

Code resolution = Database register in SAP that links the spare part number for a Wärtsilä product to the actual material installed on the Wärtsilä product

1 INTRODUCTION

This chapter presents an overview of the thesis work, including the purpose and problem area behind the thesis. Followed by this the delimitations and confidentiality will be discussed. At the end of the chapter the overall disposition of the thesis will be presented, giving a better understanding of the composition.

1.1 Background

This thesis is made on the behalf of Wärtsilä 32 Technical service, which is a part of the Wärtsilä corporation. Wärtsilä is always striving towards excellence, this includes the Service segments fast and precise customer support. In today's industrial society customer support is a critical factor for expanding a business and keeping the existing customers satisfied.

Currently, when an engine block needs replacement in the field, there are no clear instructions for which engine block cast can replace which, and according to which drawing the engine block should be phased out. An engine block that was casted 20 years ago will not have the exact same features as the ones casted in the factory today.

There have been occasions when problems with the compatibility between an old and new engine block have occurred at the site of the installation. For example, holes for attaching critical parts to the engine block may have changed, either in size or location, during the updates to main drawings under the years. This creates a scenario where both the customer and Wärtsilä lose time and money, trying to figure out which parts needs modification and which parts that can replace the inaccurate ones.

1.2 Purpose

The purpose of this thesis is to create a replacement matrix and a plan for a spare part stock optimization for Wärtsilä 32 engine blocks. As of today there are no specific replacement chains available for replacing engine blocks between different design stages. The result of this thesis will work as an aid for the Technical Service department at Wärtsilä leading to faster technical support, easier spare part handling, cost optimization and better competitiveness in the future.

Main targets

- Updated internal TS documentation to enable faster technical support during engine block orders and replacements.
- Proposal for engine block compatibility between design stages and instructions for parts to be phased out.
- Possible suggestions for new engine block assemblies.

1.3 Delimitations

This thesis is ordered by Wärtsilä 32 technical service, hence the focus will lie only on engine blocks of the W32 model and all its design stages.

Main bearing caps, cylinder liners, cylinder head screws and similar parts that are of great importance for the functionality of the engine block as a whole will also be taken into consideration.

1.4 Confidentiality

This thesis handles sensitive information such as internal material numbers and drawing numbers which are not to be shared outside the Wärtsilä organization. Therefore, in this thesis, all critical information will consist of made up numbers, only exemplifying the end result.

1.5 Disposition

The first chapter gives the reader an introduction to the background, problem area and purpose of the thesis. Confidentiality and delimitations were also briefly introduced.

The second chapter will present the theoretical structure behind the paper.

The third chapter will introduce the reader to the methods used to achieve the end result. This includes interviews and data collection.

The fourth chapter will present the final result of this thesis.

The fifth chapter consists of a discussion of the thesis overall. The final result will also be reviewed. This chapter will also include some proposals for further development.

1.6 Wärtsilä in brief

Wärtsilä was founded in 1834 in the municipality of Tohmajärvi as a small sawmilling company. Wärtsilä have been involved in many different markets throughout the years but today their main focus is smart technologies and complete lifetime solutions for the marine and energy markets, which the company is a global leader in. (Wärtsilä, History, 2018)

Their main goal is to maximize the environmental and economic performance of the vessels and power plants of their customers. This is done by emphasizing sustainable innovation, total efficiency and data analytics.

In 2017, Wärtsilä's net sales totalled EUR 4,9 billion with approximately 18,000 employees. The company are active in over 200 locations in more than 80 countries worldwide. Wärtsilä is divided into three company segments, Marine solutions, Energy solutions and Service. (Wärtsilä, About Wärtsilä, 2018)

1.6.1 Wärtsilä Marine Solutions

Marine solutions provide the customers in the marine oil & gas industry with innovative products and integrated solutions that are safe, environmentally friendly, sustainable, flexible and economically sound. These products include multiple fuel vessels, thrusters and propellers, but marine solutions also provide complete ship designs and maintenance agreements.

1.6.2 Wärtsilä Energy Solutions

Wärtsilä energy solutions is a leading global energy system integrator, offering a wide range of environmentally sound solutions. Energy solution's portfolio includes flexible internal combustion engine based power plants, solar PV power plants, energy storage & integration solutions and also LNG terminals and distribution systems. All of these solutions strive towards a more sustainable and modern energy system.

1.6.3 Wärtsilä Services

Wärtsilä Service segment provides high-quality support throughout the whole lifecycle of their products. Services supports both shipping and power generation companies, around the clock. Solutions range from spare parts and basic support to installations, all in a safe, reliable and environmentally sustainable way. (Wärtsilä, About Wärtsilä, 2018)

1.6.4 Wärtsilä 32 Technical Service

The Wärtsilä 32 technical service team to which this thesis is made consists of 11 employees whom are responsible for supporting the customers operation and maintenance with focus on economy and safety for the Wärtsilä 32 and Vaasa 32 engine models. The technical Service team is supported by the Automation and Auxiliary System experts, Component and System Experts and Condition Based Maintenance. The support is given in the form of root-cause analyses and in-house component as well as engine and system site investigations globally. In addition to this the department uses a customer support portal called Techrequest where technical support is given online.

2 THEORY

2.1 Qualitative research

Qualitative research is the process in which the researcher systematically examines and arranges his or her data material (for example interview transcriptions, field notes or other material) in order to come to a conclusion. In the qualitative analysis the researcher actively works with his or her data, arranging it, breaking it down, coding it, making syntheses and looking for patterns in it. (Bogdan & Biklen, 2007)

The challenge in qualitative research is making sense out of a massive amount of data. It is about distinguishing between the significant and the trivial and identifying meaningful patterns. There are no absolute rules when it comes to qualitative analysis, except maybe the following:

“Use your whole intellect to justifyingly represent your data and communicate what the data shows according to the purpose of your study.”

Applying guidelines to your analysis creates demands on both your judgement and creativity. Since every qualitative study is unique, the analytic way of working will be unique. The human elements in qualitative research create both strengths and weaknesses when it comes to the end result. One of the strengths is for example that it allows human insights and experiences which can create completely new understandings and ways of looking at the problem in question. Weaknesses represented by the human elements can for example be that the end result is very dependent of the researcher’s skills, education, intellect, self-discipline and creativity. (Patton M. , 2002)

2.1.1 Qualitative data

The term *data* in qualitative research refers to the rough materials that the researcher collect from the world he or she is studying. The collected data are the particulars that form the foundation of the analysis. This includes all material that the researcher doing the study actively records, both interview transcripts and field notes but also data that others have already created such as official documents, photographs and so on. (Bogdan & Biklen, 2007)

The processes of analysis and interpretation of the data involve disciplined study, creative insight and careful attention to the purposes of the evaluation. These two, the analysis and interpretation are conceptually different processes.

-*Analysis* can be defined as the process of bringing the collected data together, creating order and organizing what it contains into patterns, categories and basic descriptive units.

-*Interpretation* of the collected data includes attaching an understanding and significance to the analysis, explaining descriptive patterns and looking for connections between the descriptive dimensions.

Often there is not a precise point for when the data collection ends and the analysis begins because in the process of gathering data, ideas about the analysis and interpretation will undoubtedly occur. These thoughts will create the foundation of the future analysis. This phenomenon of overlapping will improve both the quality of the data collected but also the quality of the final analysis as long as the researcher is careful not to let the first interpretations of the data collection interfere with the final analysis. (Patton M. , 1987)

Kvale (1997) defines five main methods for analysis of qualitative data. These methods relate primarily to data collected from qualitative interviews but Kvale's list can also be used as a simple and foreseeable map of how to analyze qualitative data more generally. (Frejes & Thornberg, 2009). The five methods consist of:

1. Concentration

The collected data material is concentrated by converting the essential contents of the data to a fewer amount of words. This means that the researcher focuses on generating one or a few pithy core sentences from all the collected data.

2. Categorizing

The collected data material is coded into categories. The data is reduced and structured to a fewer amount of categories by analyzing similarities and differences in the collected data.

3. Narrative

The collected data material is organized both socially and contemporary. This method rely on and expands the stories that are told by the interviewed subjects. In some cases the researcher tries to create a coherent story of the many events that appear or are described in the collected data.

4. Interpretation

The researcher tries to look past the core contents in the collected data material, resulting in in deeper and more or less speculative interpretation of the data. The researcher will in this method use some kind of context to interpret a specific piece of data. The frame of reference in this case can for example be the entire collected data material (when looking at a specific piece of data) or one or a few theories.

5. Ad Hoc

In this method the researcher combines two or more of other alternatives of analysis methods to create meaning of the data material. Instead of just using a single standard method for analysing the data, one varies between different methods. Example of methods that can be used is finding patterns or themes, make compilations, create metaphors, count, create contrasts or build a logical chain of evidence. (Kvale, 1997)

A sixth method of analysing collected data called *Modelling* can according to (Frejes & Thornberg, 2009) be added to this list. The researcher creates different concepts and analyses the relations between these, leading to theoretical reasoning or a theoretical model which can describe how things tie up with each other and why things occur the way they do in the collected data material.

2.2 Logistics

Modern logistics at its heart deals with satisfying the customer. Customer satisfaction is the most important output of an organization's logistics system and, for this system to work, management must understand the requirements surrounding their logistics chain. In a more practical sense, logistics refers to the systematic management of the various activities required to move benefits from their point of production to the customer. These benefits are often in the form of products that needs to be manufactured and delivered to the customer. In some cases the benefits can be intangible, meaning that the benefits consists of different kinds of service. (Gourdin, 2001)

Shapiro, Roy D & Heskett, James L (1985) similarly define logistics as:

“The continuous process of meeting customer needs by ensuring the availability of the right benefits for the right customer, at the time and place the customer wants them, all for a price the buyer is willing to pay”

2.2.1 Components of a logistics system

The meaning of logistics is very wide and involve a long chain of events occurring from the beginning of a products lifecycle, as raw material and extend all the way to the support the product may get after it is delivered to the customer. Following components of the logistics system are, amongst many others, essential:

Customer service

A multi-dimensional and probably one of the most important part of a company's logistics system. In a broad sense, customer service is the output of the whole logistics system meaning that the customer service and the resulting level of satisfaction are what the logistics chain ultimately provides the buyer. This function is often seen in a narrower functional view of a company, meaning that it just is something that they actually perform. The company maybe has customer service department that handle all business connected to complaints, special requests etc. Disappointment in the customer service area may lead to dissatisfaction with the company as a whole resulting in damage to the whole logistics system.

Inventory management

This component of the logistics system deals with balancing the cost of maintaining additional products on hand against the risk of not having the products available when they are needed. The challenge involved with this component is making sure the rest of the logistics chain does not get affected from the lack of inventory, creating a scenario where, for example, the customer service suffers since inventory management is poorly handled. So, managers must make a decision whether they need additional products in a specific market and, if so, how many of each product.

Storage and materials handling

Relates to the physical requirements of holding inventory. It is not only the space needed for the stored products, it is also how the goods is handled within that space.

Information processing

This is what connects the entire logistics system together. Today many companies have linked their internal logistics systems with those of their vendors and customers, leading to more added value to the whole logistics system. This means faster order placement, quicker benefit delivery and greater accountability throughout the logistics process.

Production planning

Production planning can be included as a component in the logistics system because of the fact that manufacturing demand raw material in order to create finished goods that are demanded by the customer. Production planning is strongly connected to customer service, since the customer is in the end of the process. This means that the primary focus must in the end lie on satisfying the customer rather than trying to optimize the production as much as possible. (Gourdin, 2001)

3 METHOD

This chapter will go through the methods used to achieve the result. The method of working is a mixture between interaction with employees working with engine block replacements and data collection from internal databases.

3.1 Interviews

To get started with the thesis work I conducted several meetings, both with my supervisors from Wärtsilä but most importantly with employees that are in any way connected to the process of delivering a replacement engine block. By doing these interviews, I got insight in where and what type of problems can occur during the replacement process and I got a deeper understanding of the task in hand.

Before the interviews I prepared a few questions to get the conversation going. I chose not to have too detailed questions but instead let the conversation flow relatively freely and discuss the problems surrounding the engine block replacements in a more natural sense with the experts. During the interviews I got valuable information on what was desired from the end result of this thesis. Some of the interviews included follow up meetings while others could be followed up only by email contact, the interviews presented in this chapter are the ones that was of the greatest importance to the end result.

3.1.1 Interview with Senior Engine expert, engine structure & power systems

This was the first interview conducted for the thesis, with an expert from the department of Engine structure & power systems. Before this meeting some basic information about the engine block assemblies, castings and related drawings were collected, this data is presented in chapter 3.2.

During this interview I got valuable information about the structure of the engine block and significant changes that have been applied during the years of development of design stages. I got ideas from his point of view about what needed to be included in the end result and what kind of problems Wärtsilä is facing today when replacing an engine block but also available solutions to some of these problems.

In addition to the information about changes in the structure of the engine block I gathered information about suppliers of the unmachined engine block casts and I also got some

pointers on which persons are involved with the machining process of the casts. All of this information turned out to be very useful later on. (Interview with senior engine expert, 2017)

3.1.2 Interview with Process Developer, block manufacturing

The process developer has a lot of insight of how the machining process in the factory works and what needs to be taken into consideration during this process.

From this interview I found out the procedures related to the machining process and what the critical steps are throughout the machining process. He also explained a lot about the reasons for the changes that have been implemented to the engine block structure, what weaknesses have been corrected and what strengths have been gained. This was very helpful because I got a deeper understanding of the engine blocks construction.

In addition to this we discussed problems with the current replacement chain and the way of doing things today. During this interview I realized the value of this thesis more and more, since I got the understanding that some of the processes related to engine block replacements today depend largely on the experience of the employees working directly connected to it. (Interview with process developer, 2018)

3.1.3 Interview with Manager for Operations, Engines and components / Strategic Purchaser

This person is one of the middle hands between the customer and machining experts in the factory. The department checks availability of engine blocks in stock and is responsible for ordering the replacement casting from the manufacturer and to give the right machining instructions to the machining department according to the specifications on the engine block that is about to be replaced.

During this meeting, I got insight in the process of ordering an engine block from the engine block cast manufacturer and passing it onwards to the factory for machining. We discussed how the process works, who is responsible for what tasks and problems that might occur on the way.

It became clear that a precise replacement chain between engine block casting material numbers and instructions for parts to be phased out does not exist. (Interview with Strategic Purchaser, 2018)

3.2 Choice of platform

Microsoft Excel was the natural choice of platform to work with throughout this thesis work since I knew from the beginning that a lot of numbers, statistics and data were to be analysed. Excel is also a familiar software to more or less every employee at Wärtsilä and is relatively easy to work with when it comes to creating specific functions. In addition to these facts, Excel cooperates well with SAP, making it possible to import data directly from SAP into an excel-sheet.

3.3 Data collection

The foundation of this thesis work persists of assembly material numbers, engine block casting numbers, main drawings and assembly drawings. To get started with the gathering of information that would be used in this thesis many hours were spent sorting out all existing engine block assemblies that could be found in SAP. The search was done with the specific spare part number that Wärtsilä uses for the engine block.

	A	B	C	D	E	F	G	H	I	J	K	L	M
	Product No	Section	Production Module	SPN	SPN Description	Material as-is	Material Description	Cylinder Information	Product type	Reference Type	Product Type Extension	Quantity per Section	Quantity per product
1													
2	1234	100-011	1234A123456	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
3	1235	100-012	1234A123457	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
4	1236	100-013	1234A123458	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
5	1237	100-014	1234A123459	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
6	1238	100-015	1234A123480	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
7	1239	100-016	1234A123481	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
8	1240	100-017	1234A123482	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
9	1241	100-018	1234A123483	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
10	1242	100-019	1234A123484	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
11	1243	100-020	1234A123485	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
12	1244	100-021	1234A123486	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
13	1245	100-022	1234A123487	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
14	1246	100-023	1234A123488	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
15	1247	100-024	1234A123489	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
16	1248	100-025	1234A123470	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
17	1249	100-026	1234A123471	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
18	1250	100-027	1234A123472	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
19	1251	100-028	1234A123473	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
20	1252	100-029	1234A123474	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
21	1253	100-030	1234A123475	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
22	1254	100-031	1234A123476	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
23	1255	100-032	1234A123477	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
24	1256	100-033	1234A123478	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
25	1257	100-034	1234A123479	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
26	1258	100-035	1234A123480	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
27	1259	100-036	1234A123481	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
28	1260	100-037	1234A123482	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
29	1261	100-038	1234A123483	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
30	1262	100-011	1234A123484	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx
31	1263	100-011	1234A123485	100000	Engine block	1010B101010	ENGINE BLOCK ASSEMBLY	GEN	W12V32	W32	-	xx	xx

Figure 1 List of existing engine block assemblies for W12V32 configuration

With the help of the SPN and the product type as a reference in the search all existing engine block assemblies could be identified and transferred into one excel-sheet, as seen in figure 1. This procedure was repeated for all W32 configurations. The result of the search reveals which Product No, i.e. which specific engine number is equipped with which engine block assembly number.

When all available engine block assemblies had been imported from SAP it was time to start to narrow down the technical specifications of each assembly. At first the most basic and simple information, like drawing number, casting material number and design stage, of every assembly of each engine configuration was gathered into a table, making it easier to overlook possible similarities between the available assemblies. Most of this information was accessible from PDM but some information, like the design stages, had to be searched for in an internal Wärtsilä 32 engine excel list.

	Assembly mat. Nr	Engine block casting	Engine block main drawing	Assembly drawing	Design stage	Info	Material
	123456789	112288335	V11A1111	V1231111	B, B2		Material
	123456790	112233455	V11B1111	V1232222	B3, C, D		Material
	123456791	112233455	V11B1111	V1233333	B2		Material
	123456792	223344551	ABCD000001	V1234444	C, D		Material
	123456793	445566778	ABCD000022	V1235555	E		Material
	123456794	445566778	ABCD000022	V1236666	E2		Material
Total	6	4	4	6			

Figure 2 W12V32 engine block assembly overlook

As can be seen in Figure 2, after narrowing the results imported from SAP, it was found that for the W12V32 engine configuration there are six different engine assemblies. These assemblies use four different engine block castings and cover the whole range of design stages. Here one can see that, for example, engine block casting material number “112233455” is used in design stages B2, B3, C and D which is an indication of that it is compatible as a replacement block between at least these design stages.

After creating a table like the one in Figure 2 for all engine configurations it was time to get more specific and start listing the differences in the structures of the engine blocks to get a better understanding of where and what problems may occur when mixing an old engine block with the ones produced today.

Design stage	Camshaft bore Ø	Cylinder head screws	Intermediate gear bearing Ø	Cylinder liner Ø
B	xxx	Mxx	xxx	xxx
B2	xxx	Mxx	xxx	xxx
B3	xxx	Mxx	xxx	xxx
C	xxx	Mxx	xxx	xxx
D	xxx	Mxx	xxx	xxx
E	xxx	Mxx	xxx	xxx
E2	xxx	Mxx	xxx	xxx

Figure 3 Engine block structural differences between design stages

Main bearing cap					
Design stage	Cast width	Machined width	Casting	Drawing nr	Machining drawing Mb screw
B	xxx	xxx	xxxxxxxxxx	A10B1010	Mxx
B2	xxx	xxx	xxxxxxxxxx	A10B1010	Mxx
B3	xxx	xxx	xxxxxxxxxx	A10B1010	Mxx
C	xxx	xxx	xxxxxxxxxx	A10B1010	Mxx
D	xxx	xxx	xxxxxxxxxx	A10B1010	Mxx
E	xxx	xxx	xxxxxxxxxx	A10B1212	A11B1111 Mxx
E2	xxx	xxx	xxxxxxxxxx	A10B1212	A11B1111 Mxx

Figure 4 Main bearing cap design stage differences

To start with, a table like the ones seen in Figure 3 and 4 was created for each engine configuration. The choice of components and critical structural parts in the engine block to be looked at was concluded during the interviews. The list was created based on measurements and specifications in engine block main drawings from engines from all different design stages. To assure the accuracy of the values, a selection of engines and drawings were checked from every design stage.

This step was of the outmost importance for reaching a satisfying result, since the changes between different design stages became more clear and similarities and variations in the structure could be identified. This step of the process revealed that the newest design stages (E, E2) have slightly different dimensions than the other design stages when it comes to cylinder liners, cylinder head screws, main bearing caps and main bearing cap screws, all of which was useful information going forward with the task.

Assembly mat. Nr	Engine block casting	Engine block main drawing	Main drawing revisions	Assembly drawing	Casting drawing	Design stage	Camshaft bore	Intermediate gear bearing Ø	Cylinder head screw size	Cylinder liner Ø	Main bearing cap size	Material
123456789	112288335	V11A1111	6 pc, first 1995, latest 2001	V1231111		B, B2	xxx	xxx	Mxx	xxx	xxx	Material
123456790	112233455	V11B1111	2 pc, first 2004, latest 2005	V1232222		B2	xxx	xxx	Mxx	xxx	xxx	Material
123456791	112233455	V11B1111	13 pc, first 2004, latest 2014	V1233333		B3, C, D	xxx	xxx	Mxx	xxx	xxx	Material
123456792	223344551	ABCD000001	12 pc, first 2010, latest 2016	V1234444	ABCD0001	C, D	xxx	xxx	Mxx	xxx	xxx	Material
123456793	445566778	ABCD000022	12 pc, first 2010, latest 2016	V1235555	ABCD0002	E	xxx	xxx	Mxx	xxx	xxx	Material
123456794	445566778	ABCD000022	12 pc, first 2010, latest 2016	V1236666	ABCD0002	E2	xxx	xxx	Mxx	xxx	xxx	Material

Figure 5 W12V32 engine block assembly overview

After compiling the design stage specific data for each engine configuration, the information needed to be connected to the specific engine block assemblies. This was done so that the end result, presented in Chapter 4, would give out the correct information about what specifications an engine block assembly consists of when searching for an assembly in order to get a clear overview over both the specifications of the customers' existing setup versus the replacement setup. To this table the number of revisions for the main drawings were also added because the revisions give information about changes that have been implemented during the years of development. This is presented in Figure 5.

3.4 Creating the configurator

After all necessary data for the engine block assemblies and castings had been collected it was time to figure out how to make the data as easily accessible and understandable as possible. Ideas on how the layout of the information should look was discussed together with my supervisors from Wärtsilä and it was decided that, in addition to making the tables of information created for each engine configuration more foreseeable and keeping them in the file, a search function would be created. The purpose of the search function was to make it faster and easier to access the wanted data, without having to look through whole tables.

To do this, all of the collected data was arranged in a separate excel sheet and using the VLOOKUP-function in excel the data was connected.

3.5 Recommended stock level

When it came down to creating a recommended stock level for the engine blocks, it was clear that the stock number would be quite low. This is because of the fact that an engine block seldom needs to be replaced. The recommendation for a stock level of engine blocks was decided based on the current status of engine blocks in the field together with statistics of engine blocks sold. This information was gathered from SAP. The smaller the percentage of engine blocks sold in ratio to the amount in the field, the lower the number of stock level.

4 RESULT

In this chapter the result of this thesis work will be presented. The functions and layout of the configurator will be shown and explained.

4.1 Start page

The layout of the start page can be seen in Figure 6. The design is simple and includes two options of searches with different outcomes, depending on what information the user is looking for.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Engine block replacement search											
2												
3												
4	<input type="text"/>				Engine configuration							
5	<input type="text"/>				Assembly nr							
6												
7												
8					Search assembly							
9												
10												
11												
12	or											
13												
14	<input type="text"/>				Casting material nr							
15												
16												
17	Clear cells				Search casting							
18												
19												
20												
21												
22												

Navigation bar: Start | Engine block info | Casting info | W6L32 | W7L32 | W8L32 | W9L32 | W12V32 | W16V32 | W18V32 | W20V32

Figure 6 Start page

The start page includes three buttons:

- **“Search assembly” button**, to be used when the user is searching for an existing assembly. This function will use the filled in information in the boxes “engine configuration” and “assembly nr” and send the user to the sheet “Engine block info”.
- **“Search casting” button**, to be used when the user only wants to get information about a specific engine block casting or if the assembly number is unknown. This function will open the sheet “Casting info”.

- **“Clear cells” button**, will erase the data in the search fields.

4.2 Search assembly function

This function lets the user search for engine block assembly information by filling in two fields of information.

The screenshot shows a web form titled "Engine block replacement search". It has two main input fields: "Engine configuration" and "Assembly nr". The "Engine configuration" field is currently open, displaying a list of engine configurations: W6L32, W7L32, W8L32, W9L32, W12V32 (highlighted), W16V32, W18V32, and W20V32. A "Search assembly" button is located below the "Assembly nr" field.

Figure 7 Search assembly function, configuration choice

First, as seen in Figure 7, the desired engine configuration is chosen by either writing the configuration directly in the field or by choosing from a drop-down list which is generated when the cell is activated.

The screenshot shows the same "Engine block replacement search" form. The "Engine configuration" field now contains the text "W12V32". The "Assembly nr" field is open, displaying a list of assembly numbers: 123456789, 123456790, 123456791, 123456792, 123456793, 123456794, 123456795, and 123456796. The "Search assembly" button remains visible.

Figure 8 Search assembly function, assembly choice

When the desired configuration is chosen, in this example “W12V32”, a drop-down list is generated in the “assembly nr” field which contains all available engine block assemblies for the W12V32 engine.

4.2.1 Engine block info

When the desired engine configuration and assembly number has been chosen and the user press the search button, the view seen in Figure 9 will appear.

Engine block info										
		Existing	Replacement							
Assembly:		123456789								
Configuration:		W12V32	W12V32							
Block casting:		112288335	445566778							
Main drawing:		V11A1111	ABCD000022							
Revisions:		6 pc, first 1995, latest 2001	2pc, first 2014, latest 2106							
Assembly drawing:		V1231111								
Casting drawing:		-	ABCD00001							
Design stage:		B, B2	X							
Cylinder head screw size:		Mxx	Mxx							
Camshaft bore:		xxx	xxx							
Cylinder liner:		xxx	xxx							
Intermediate gear bearing:		xxx	xxx							
Material:		Material	Material							
Main bearing cap size:		xxx	xxx							
Drawing:		A10B1010	A20B2020							
Mb screw:		Mxx	Mxx							
Additional info:	Additional information about compatibility.									

Figure 9 Engine block info

Based on the specifications of the customers' existing engine block assembly, the "engine block info" sheet will present a suitable replacement block. The result gives a clear overview of differences in critical components and structure of the engine block between the existing and replacement block. The replacement block suggestion will always be one of the engine blocks that are available for production today, i.e. from one of the newer design stages, since old engine blocks nowadays are obsolete and not available.

The "additional info" field contains information about parts that may not be compatible between the two and what measures need to be taken. For example, if the replacement engine block has holes drilled that the existing block does not have, a suggestion for a material number for a suitable plug can be shown.

4.3 Search casting number function

In case the user does not have an assembly number available or just need to get information about a specific engine block casting, the second function seen on the front page can be used.

Figure 10 Search casting number function, casting choice

When the cell is activated, a drop-down list with all available engine block casting material numbers appears. The user can choose from this list or write in the desired material number manually. The search function opens the sheet "casting info" which can be seen in Figure 11.

Figure 11 Engine block casting info

From this view, the user gets information about the searched casting and gives the user information about what machining alternatives are available for the casting. In some cases, there are more than one available main drawing for the specific cast, so the differences between the most critical components and structure between the two will be shown. This function is helpful when it comes to the decision making about on according to which main drawing the engine block should be machined.

4.4 Recommended stock level

For the recommended stock level suggestion for W32 type engine blocks a table like the one seen in Figure 12 was created.

Recommended stock level					
Engine type	In field	% of tot. in field	Sold	Sold % of in field engines	Recommended stock level
W6L32	x	x	x	x	x
W7L32	x	x	x	x	x
W8L32	x	x	x	x	x
W9L32	x	x	x	x	x
W12V32	x	x	x	x	x
W16V32	x	x	x	x	x
W18V32	x	x	x	x	x
W20V32	x	x	x	x	x
	xx	100,00%			

Figure 12 Recommended stock level for W32 engine blocks

As already suspected in the beginning, the amount of engine blocks that should be kept in stock are very few. There are mainly two reasons for this. The first reason is that keeping an engine block in stock requires a lot of space since it is the largest and heaviest component of the engine. The second and the most significant reason for the small amount that should be kept in stock is that per the statistics, engine blocks quite rarely need replacement in the field. Keeping these facts in mind, the inventory for engine blocks can not be equal to nothing, since the lead time for ordering an engine block from the casting manufacturer and getting the casting machined to right specifications is a time-consuming process.

5 DISCUSSION

5.1 Summary

The main goal with this thesis work was to create a tool for giving faster technical support during engine block orders and replacements. The result is a configurator in excel where the user can search for the desired engine block assembly and get information about differences in the structure of both the customers' existing engine block and the replacement block, making it easier to decide about the compatibility between the two. In case there is only one type of engine block casting available in stock, the function for searching engine block casting info can be used to get guidelines about what measures need to be taken for the replacement.

The process of going from knowing next to nothing about the technical specifications, dimensions and the replacement procedure of an W32 engine block to creating the configurator has not been the easiest task. Since the engine block is the foundation and largest structure of the engine, the amount of details, components and measurements are very large and before one can find a suitable replacement block there is a lot of information to cover. For reaching a conclusion for which engine block can replace which, I needed to study and learn a lot about different critical components that play a great role in compatibility.

It became clear that the engine block replacement process depends widely on the experience of the employees directly connected to it. During my work, I realized this fact and got a deeper understanding for the importance of this thesis.

In my own opinion, the result of this thesis work is satisfying. The configurator created in excel sets a good foundation for getting the engine block replacement process started, giving all necessary information for the user to know which engine block casting is compatible to which one. Ultimately, each engine block replacement is always to be checked case by case since there can be special modifications done to the engines that the "basic" information in this thesis does not cover.

5.2 Further development

During the interviews with employees from different departments a few improvement questions about the replacement process were raised. For one, the BOM for the replacement engine block is based on the spare part catalogue, which in some cases gives the customer the wrong picture of which parts will be sent with the engine block. For example, a template for a BOM for replacement blocks could be created, where the specifications for the replacement block could be filled in. In addition to this, when an engine block has been replaced in the field, there should be a clearer trace of information available in the code resolution, making it easier to identify the engine block specifications of the block currently in use in the installation.

5.3 Comments

This thesis work has given me a lot of insight in the structure of the engine but also about the whole replacement chain for critical and significant components of a product, from manufacturer of raw material to the end user. I would like to thank both my supervisors at Wärtsilä, Tony Rantamäki and Andreas Eurs, for supporting me throughout the whole thesis and Kaj Rintanen from Novia UAS for supporting me through the writing process.

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